and 4,975,919, each of which is hereby incorporated by reference). It is desired, however, to have a technique for more precisely determining spectral information such as the bandwidth, spectral purity and/or wavelength of a laser beam.

SUMMARY OF THE INVENTION

An apparatus measures a spectral distribution of a narrow-band laser beam generated by a line-narrowed excimer laser or a molecular fluorine laser system. The apparatus includes an an interferometric device disposed along an optical path of an output beam of the laser system such that the beam traverses the interferometric device on a first pass, a retro-reflector disposed after the interferometric device along the optical path for retro-reflecting the beam back through the interferometric device on a second pass, and a detector for detecting an intensity of the beam after the second pass through the interferometric device. Preferably, spectral information is determined when the free spectral range of the interferometric device is tuned and the detector measures the intensity of the beam at a plurality of free spectral ranges or when the wavelength of the output beam is tuned. A light guidance cable may also be provided for directing the beam towards the interferometric device. The apparatus may also be configured such that the beam makes a third interferometric pass prior to being incident upon the detector.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 schematically illustrates a double-pass etalon arrangement to generate very narrow band UV light for measuring the apparatus function, e.g., of a spectrometer

Figure 2 schematically illustrates this apparatus function measured by the double-pass etalon schematically illustrated at Figure 1.

Figure 3 schematically illustrates a triple-pass etalon arrangement according to a preferred embodiment.

Figure 4a shows plots of spectral apparatus functions measured by single-, double- and triple-pass etalon apparatuses; the double- and triple-pass apparatuses being according to preferred embodiments.

Figure 4b shows integrated spectra of the plots shown in Figure 4a.

Figure 5 schematically shows a double-pass etalon arrangement according to a particularly preferred embodiment.

Figure 6 schematically shows an overall excimer or molecular fluorine laser system according to a preferred embodiment.

INCORPORATION BY REFERENCE

What follows is a cite list of references which are, in addition to any references cited above in the background section or below in the detailed description of the preferred embodiments, and the background section itself, hereby incorporated by reference into the detailed description of the preferred embodiments below, as disclosing alternative embodiments of elements or features of the preferred embodiments not otherwise set forth in detail below. A single one or a combination of two or more of these references may be consulted to obtain a variation of the preferred embodiments described in the detailed description below. Further patent, patent application and non-patent references are cited in the written description and are also incorporated by reference into the preferred embodiment with the same effect as just described with respect to the following references:

United States patents no. 6,243,170 B1, 5,081,635, 4,975,919, 4,905,243, 4,926,428, 5,450,207, 5,373,515, 5,978,391, 5,978,394, 6,160,832 and 4,823,354;

F. Babin et al., Opt. Lett., v. 12, p. 486 (1987), and

R.B. Green et al., Appl. Phys. Lett., v. 29, p. 727 (1976),

U.S. patent applications no. 09/416,344 and 09/791,431

United States published application no. 2001/0013933 A1

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 schematically illustrates a double-pass etalon arrangement for measuring an apparatus function of a spectrometer, according to a preferred embodiment. A laser output beam is generated by a narrow band laser 2, or a tunable laser, or other laser wherein it may be desired to know the wavelength, bandwidth, spectral purity or other spectral parameter or other laser system wherein it is desired to measure the apparatus function of the emitted beam. The output beam generated by the laser 2 is shown in Figure 1 being incident upon and traversing an etalon 4. The etalon 4 shown is a transmissive etalon, and the arrangement shown in Figure 1 may be modified for use with a reflective etalon, such as, e.g., by re-directing the beam using a beam splitter prior to its being incident upon the etalon 4 and then disposing the retro-reflector (see below) behind the beam splitter.

The etalon 4 may be replaced by another interferometric device not including parallel plates to produce the interference spectrum. Such an interferometric device may include a pair of non-parallel, opposed reflecting surfaces or opposed reflecting surfaces that are relatively disposed in a step-like design, wherein the spacing between the plates is not constant along the entirety of the surfaces of the plates. Examples of such devices that are alternative to the etalon 4 are described at United States patent applications no. 09/715,803 and 60/280,398, which are assigned to the same assignee as the present application and are hereby incorporated by reference.

After passing through the etalon 4 on the first pass, the beam is retro-reflected back in a direction substantially anti-parallel to the direction that the beam was incident upon the retro-reflector. For example, a retro-reflection prism 6 or corner cube or corner reflector having reflecting sides substantial orientated at a 90° angle relative to each other. Preferably, these reflecting sides of the retro-reflector 6 are preferably within 0.1° or less of being perfectly normal to each other in order to achieve the desired anti-parallelism of the incident and retro-reflected beams. Other retro-reflectors such as HR